An Evaluation of Rearing Strategies for Steelhead Production at Hagerman National Fish Hatchery, Idaho

Can a Partial Recirculating Aquaculture System (PRAS) Address the Challenges of a Large-Scale Steelhead Mitigation Program?

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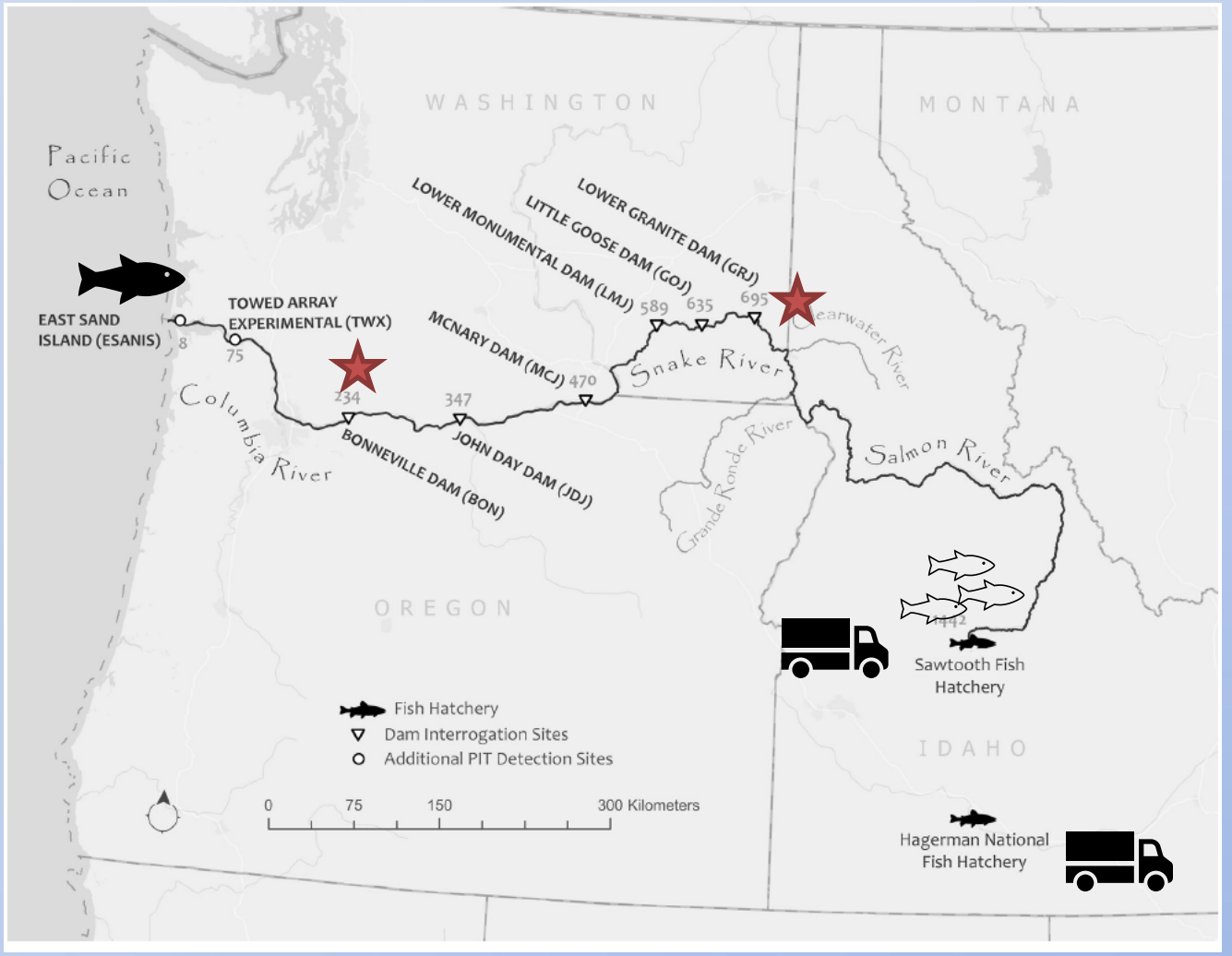
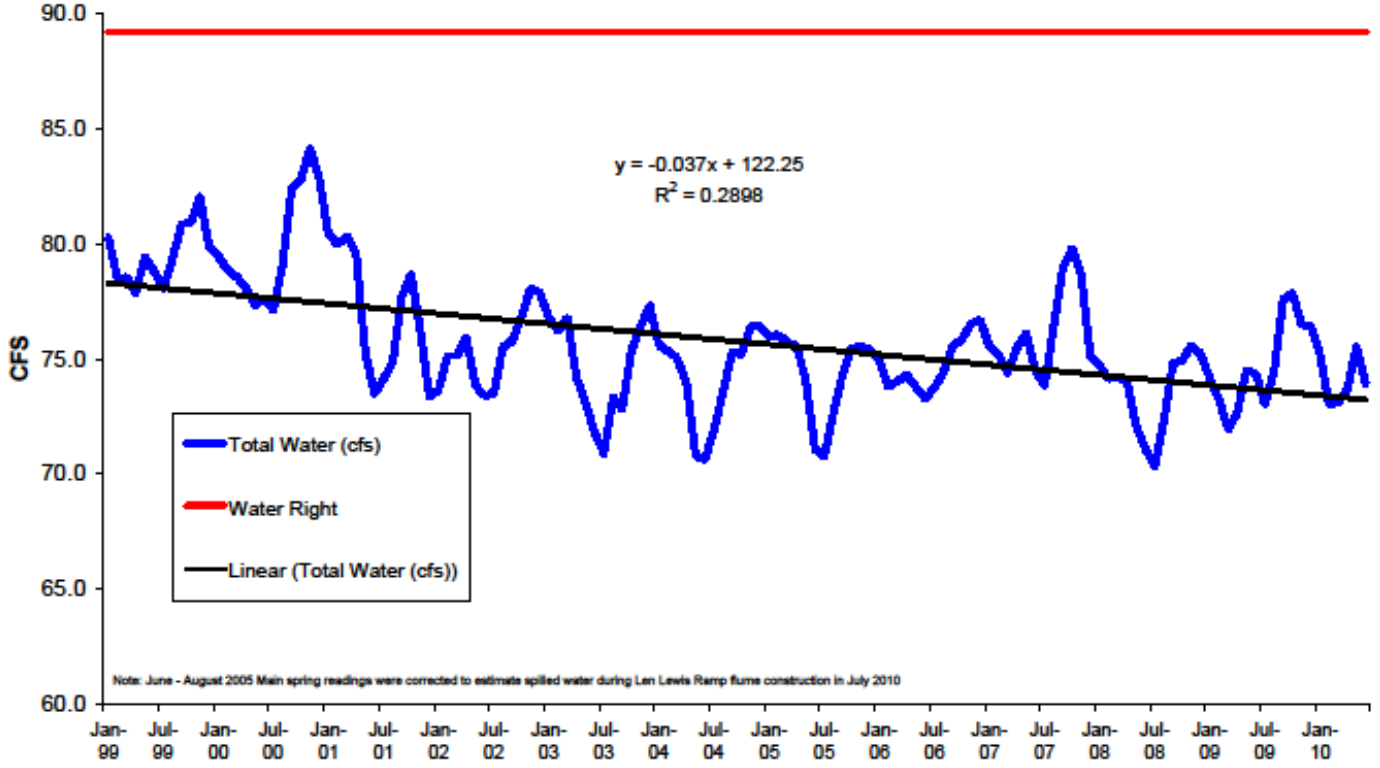
Hagerman NFH

- USFWS - Lower Snake River Compensation Plan
  - Harvest-Mitigation
- "A"-Steelhead, Upper Salmon River Basin
  - 13,600 Adults is LSRCP goal
  - 1.7 M smolt release target, age 1+ smolt release
- Adult Returns to Sawtooth Fish Hatchery - IDFG
- Water supply declining rapidly, affects production.



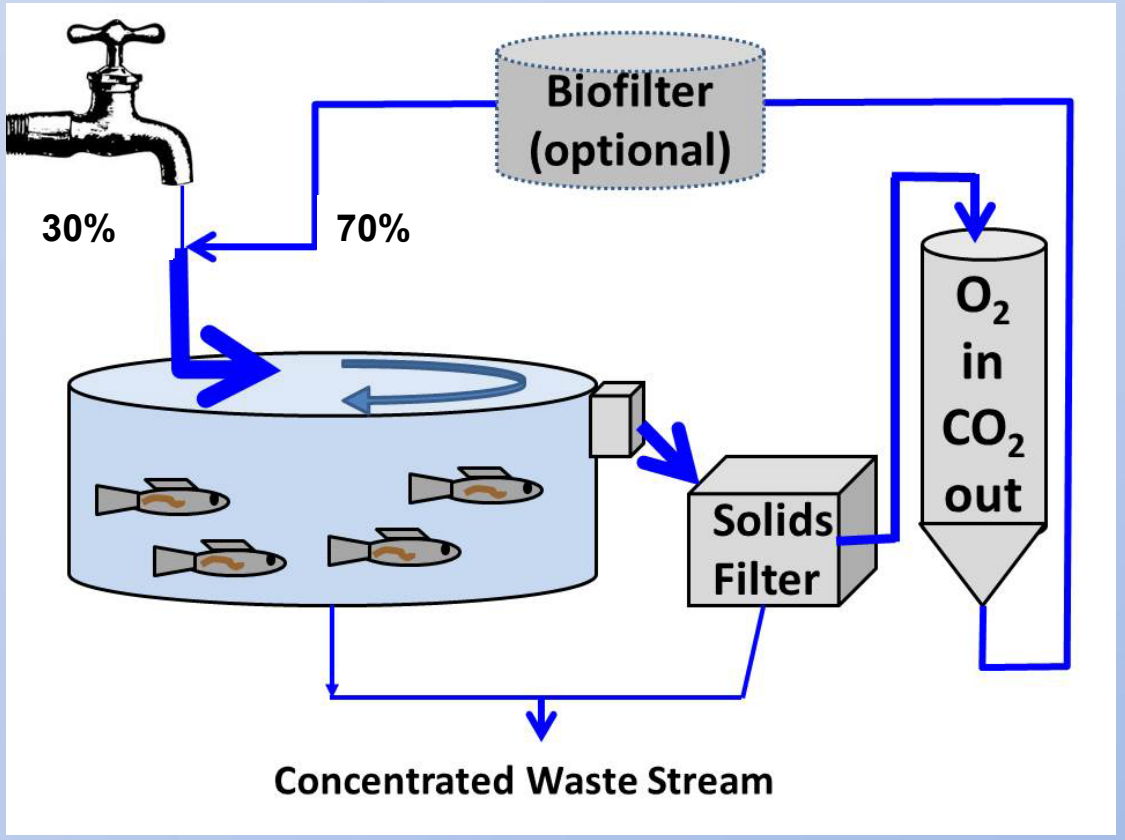
Hagerman National Fish Hatchery
Monthly Average Spring Flow, 1999-2010 (cfs)



Partial Recirculating Aquaculture System (PRAS)

- Is PRAS a practical solution to issues at Hagerman NFH?
  - Maintain or increase production with declining water supply
  - Similar or improved survival compared to existing production

- 2014 – *"Service should consider RAS whenever there is new construction or major renovation of hatcheries."*



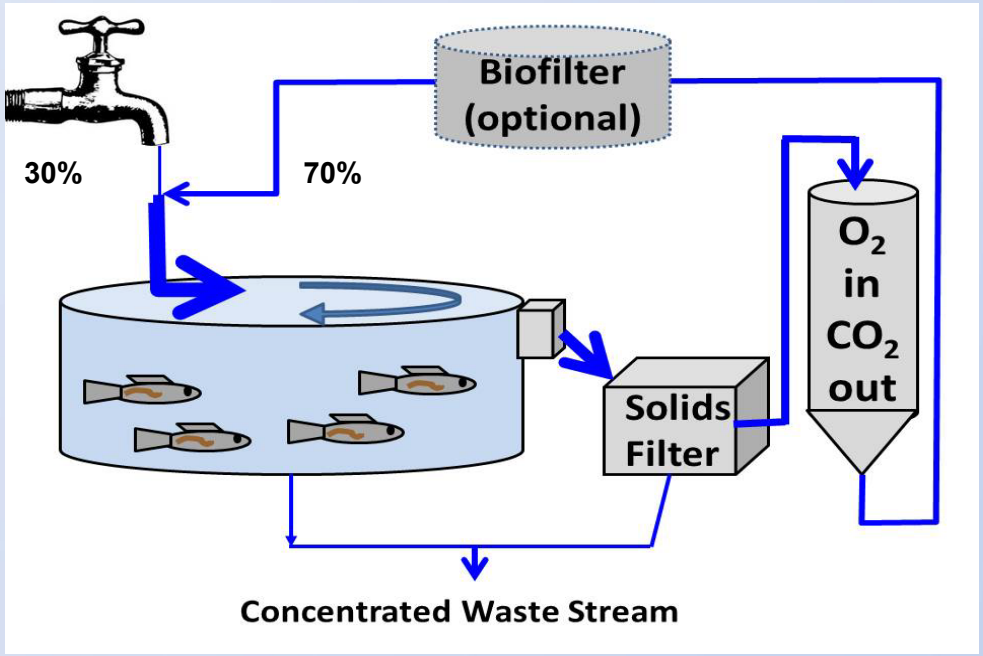
Fish Culture (HNFH)

- $13,033-$14,089 annually in energy costs
- $1.2-$1.3 M for infrastructure
- 0.6 FTE at Hagerman NFH
- Hand feeding (PRAS) vs. demand feeders (Raceways)
- Flow manipulation during rearing, monitoring.
  - 0.5 BL/sec at ponding, target 1.5 BL/sec
  - Sinking feed, changes in feed brands (+guar gum) in 2017-2018.

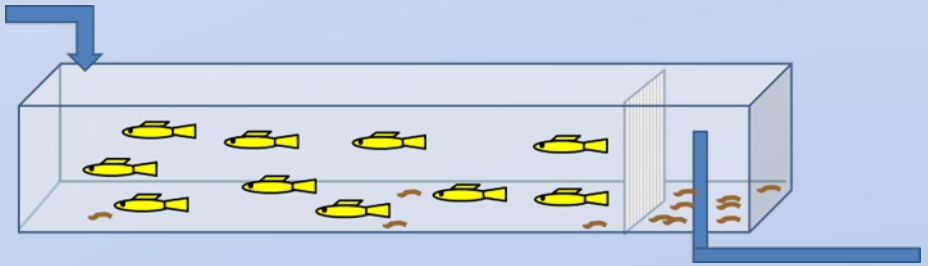
HNFH Raceways

- Dimensions - 30.5 m x 3.0 m x 0.9 m
- Less velocity than PRAS, less exercise
- Not self cleaning
- Accumulates CO_2 and ammonia
- No Phosphorus removal

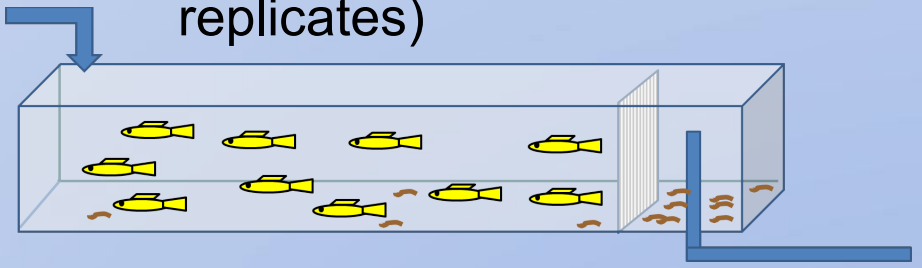
Design



PRAS (D.I. = 0.20)
-100% CWT
-8,700 PIT Tags
-90,000 (3x30K replicates)

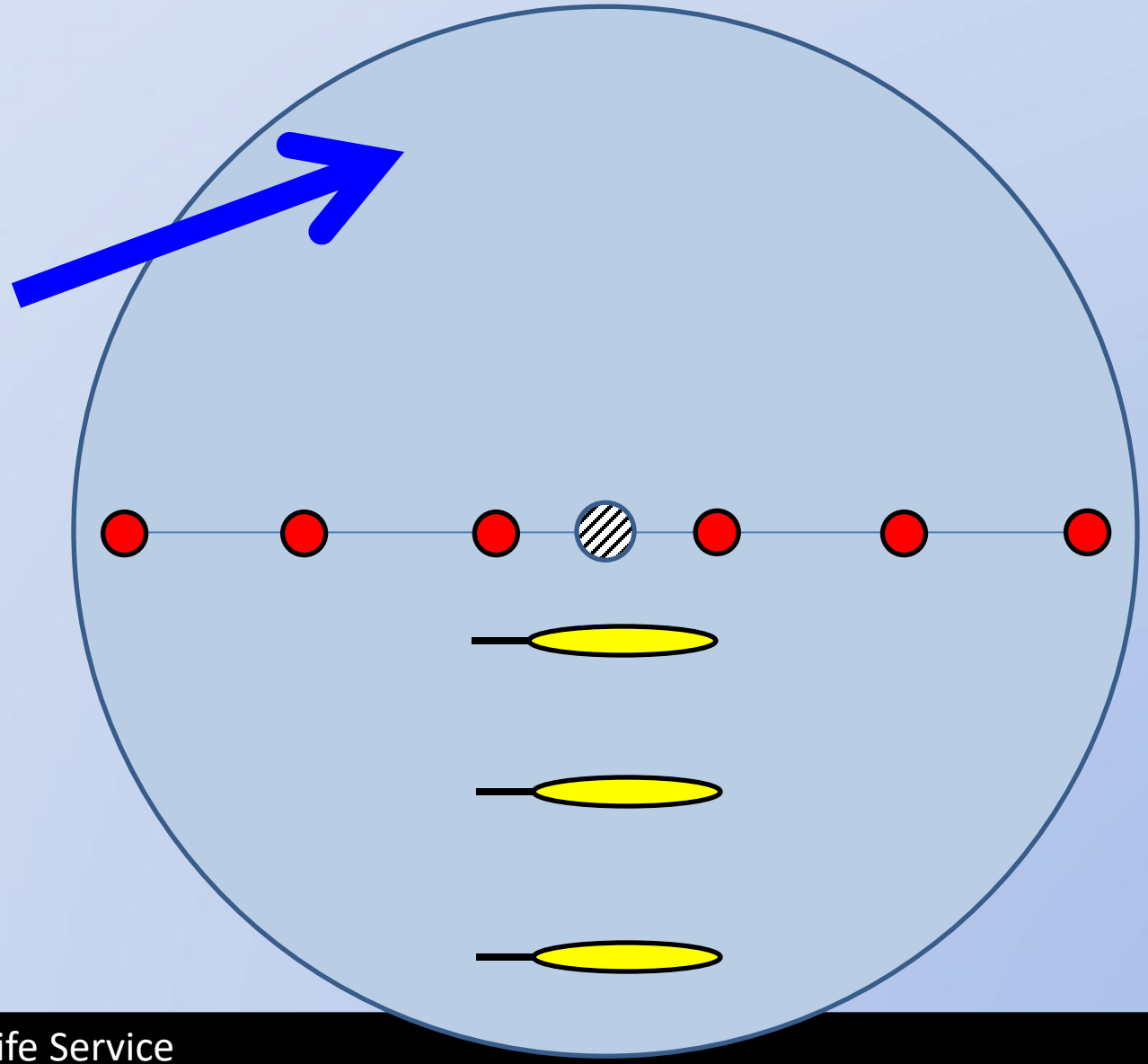


Control 1 (D.I. = 0.20)
-100% CWT and PIT
-8700 PIT Tags
-90,000 (3 or 4 x 24K replicates)



Control 2 - (D.I. = 0.24)
Production Group
-CWT and PIT
-8700 PIT tags
-1.25 M (3 x 30K replicates)

Recirculating Aquaculture (2nd Edition) – Velocities in the 0.5-2.0 fish/body length/sec



Study Plan – C. Peery 2014, USFWS – Idaho FWCO

Juvenile Fish Variables.

- Growth rate
- Condition factor
- Health/disease measures
- Survival rate (egg to smolt)
- Percent lipid/protein at release
- Density and flow indices at release
- Precocity at release
- Fin condition at release
- Smolt travel times to Lower Granite and Bonneville
- **Smolt survival to Lower Granite and Bonneville**

Adult Fish Variables

- **Smolt to adult recovery, survival (SAR, SAS)**
- Gender ratio
- Age class structure
- Homing/straying rates

Environmental Variables

Water quality/quantity
Ammonia/nitrogen
Total phosphorus
Total suspended solids
CO_2 concentration
Water Temperature
Pounds of fish reared per gallon

Fish Culture Elements

Feeding
Cleaning
Sampling
Treating
Crowding
Moving/releasing fish
Costs

Implementation?

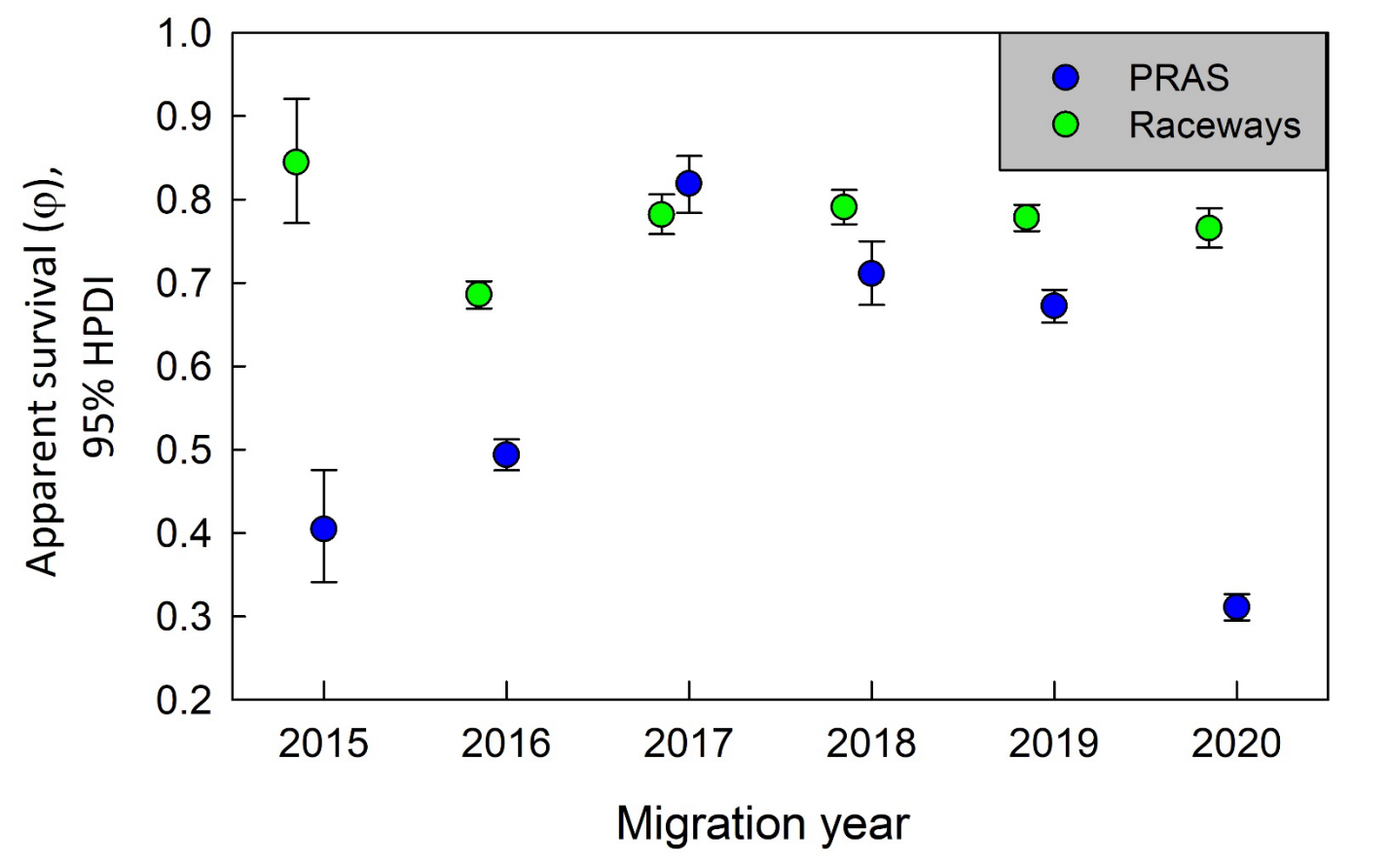
Apparent survival of outmigrating juveniles

For each migration year, we fit Cormack-Jolly-Seber (C-J-S) models to detection data at mainstem Columbia and Snake river dams using *Program MARK*

Evaluated whether apparent survival to Lower Granite Dam & Bonneville Dam varied by ***Rearing system***:

i.e., PRAS vs. Raceways [LDPC+NDC]

Juvenile Apparent Survival to Lower Granite Dam



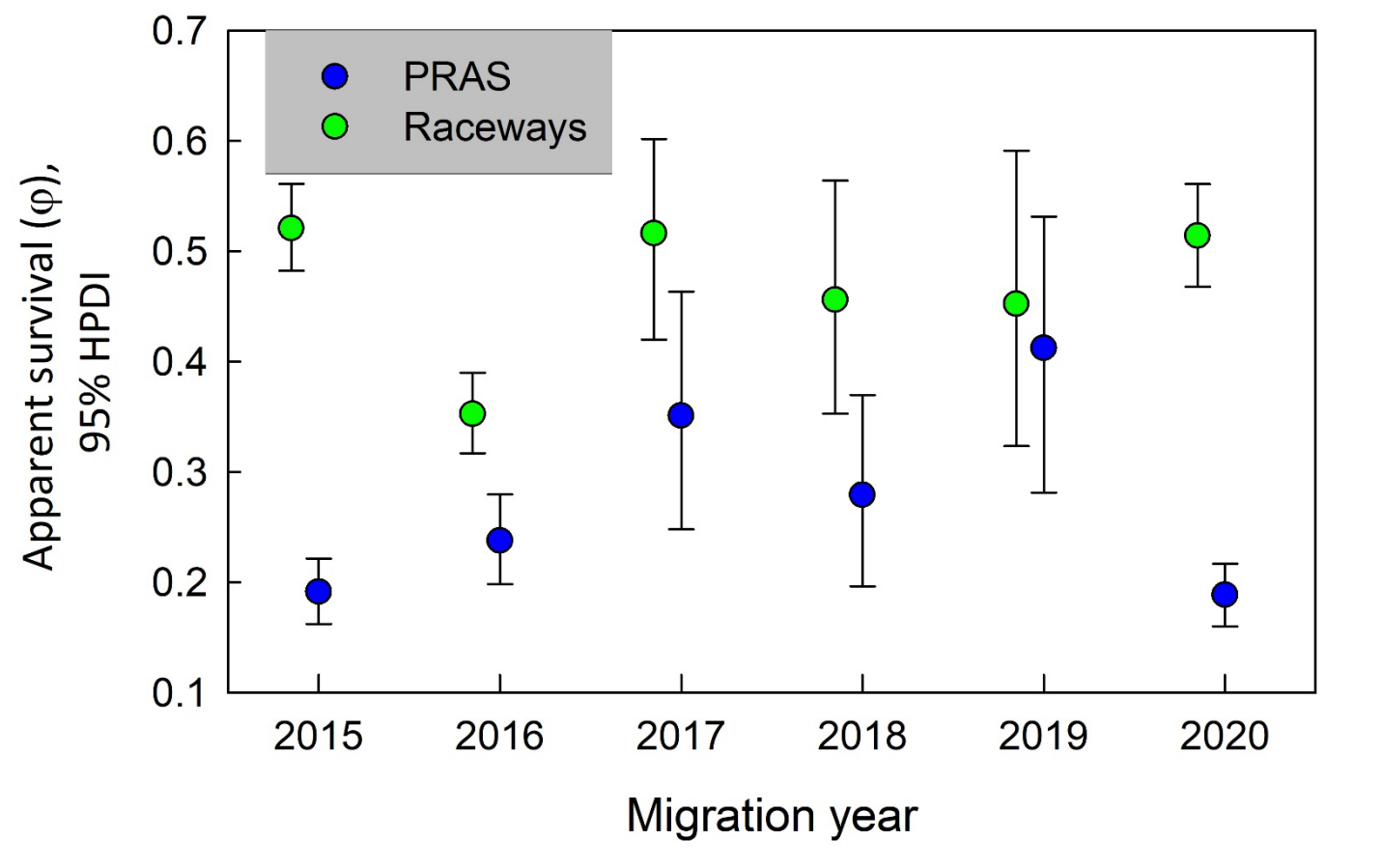
PRAS: mean 0.59 (range 0.31–0.82)

Raceways: mean 0.77 (range 0.69–0.84)

PRAS < Raceways in 5 of 6 years

Annual differences ranged 8–45%

Juvenile Apparent Survival to Bonneville Dam



PRAS: mean 0.28 (range 0.19–0.41)

Raceways: mean 0.47 (range 0.35–0.52)

PRAS < Raceways in 5 of 6 years

Differences ranged 11–33%

* In 2020, apparent

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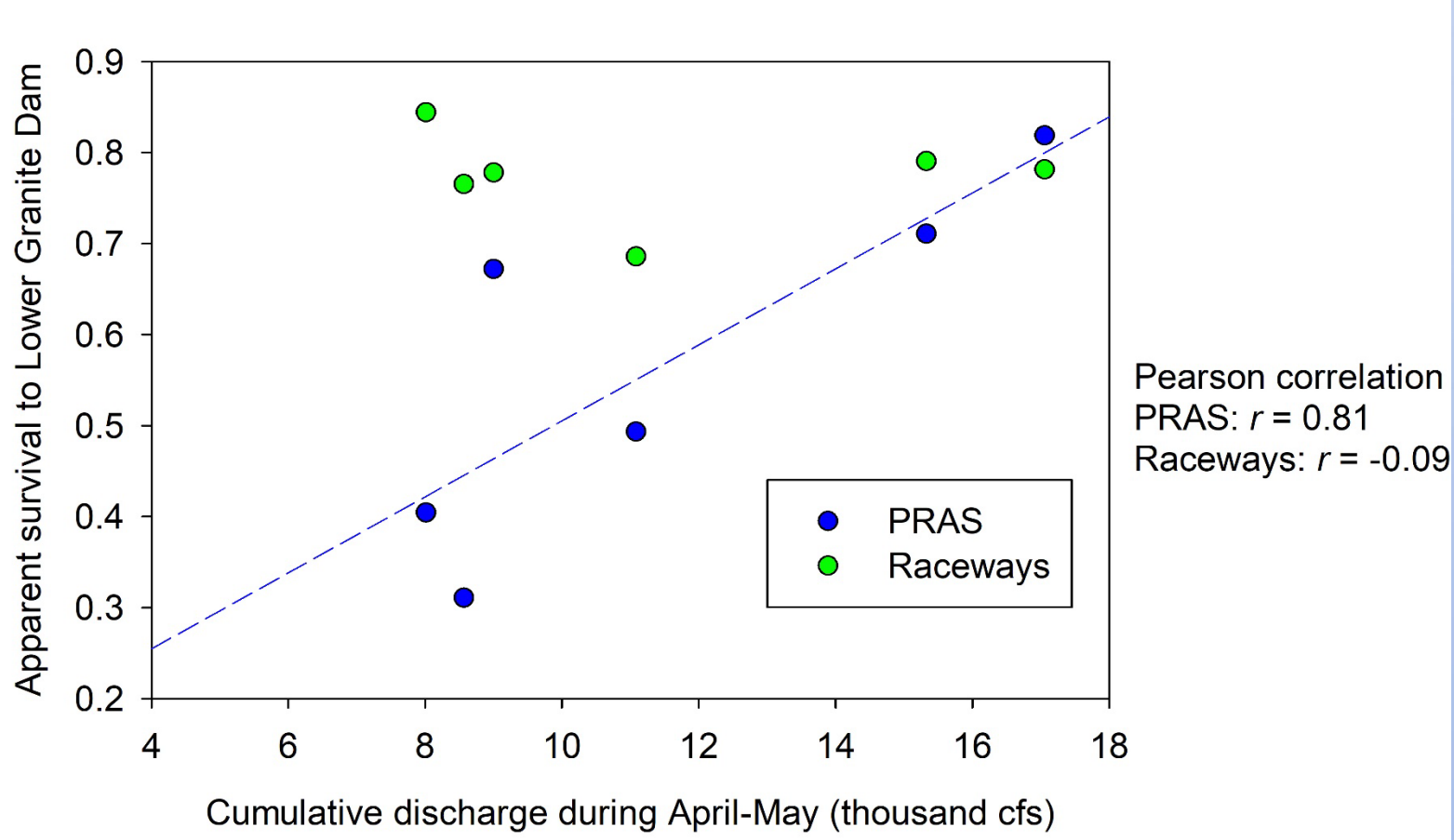
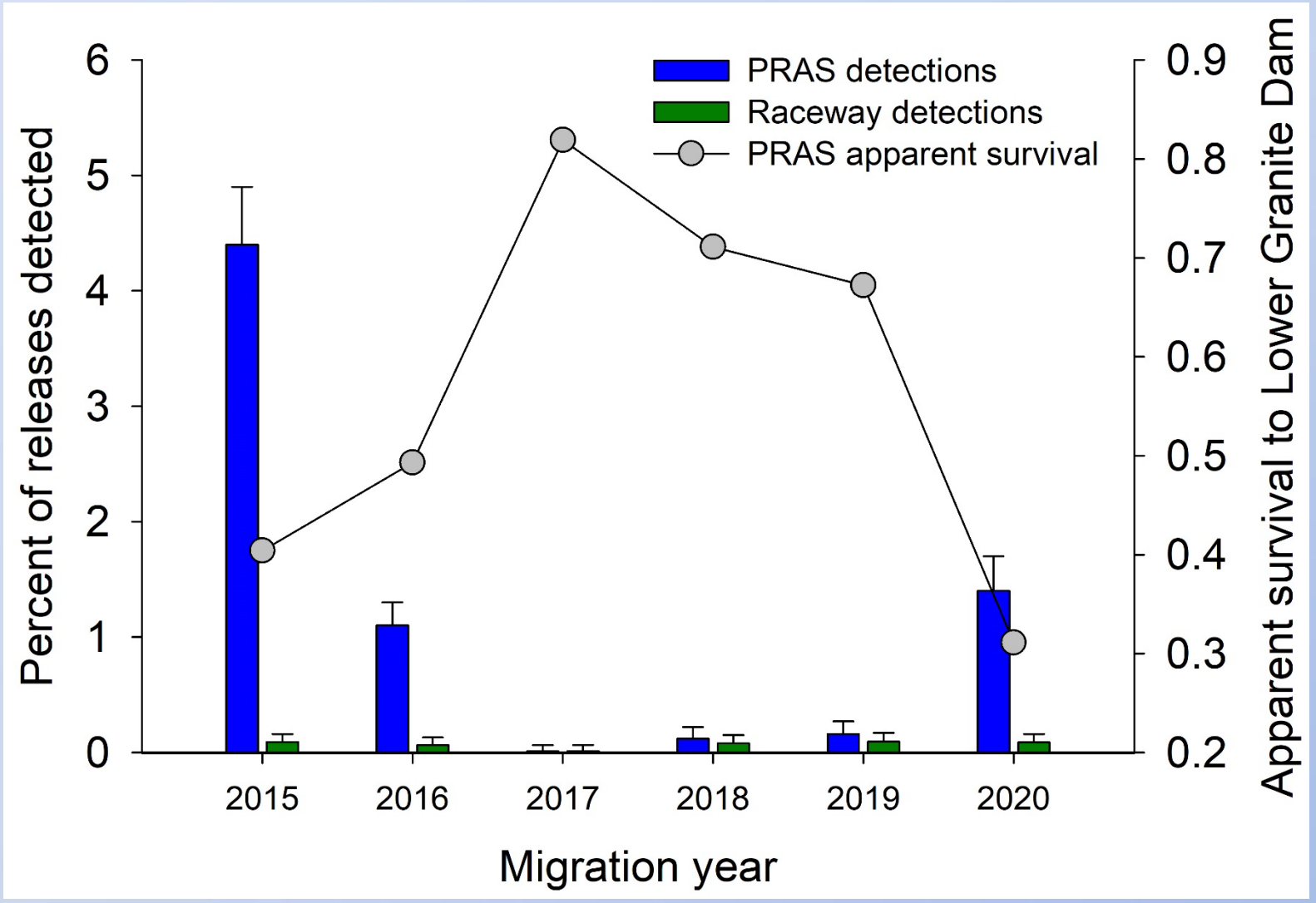
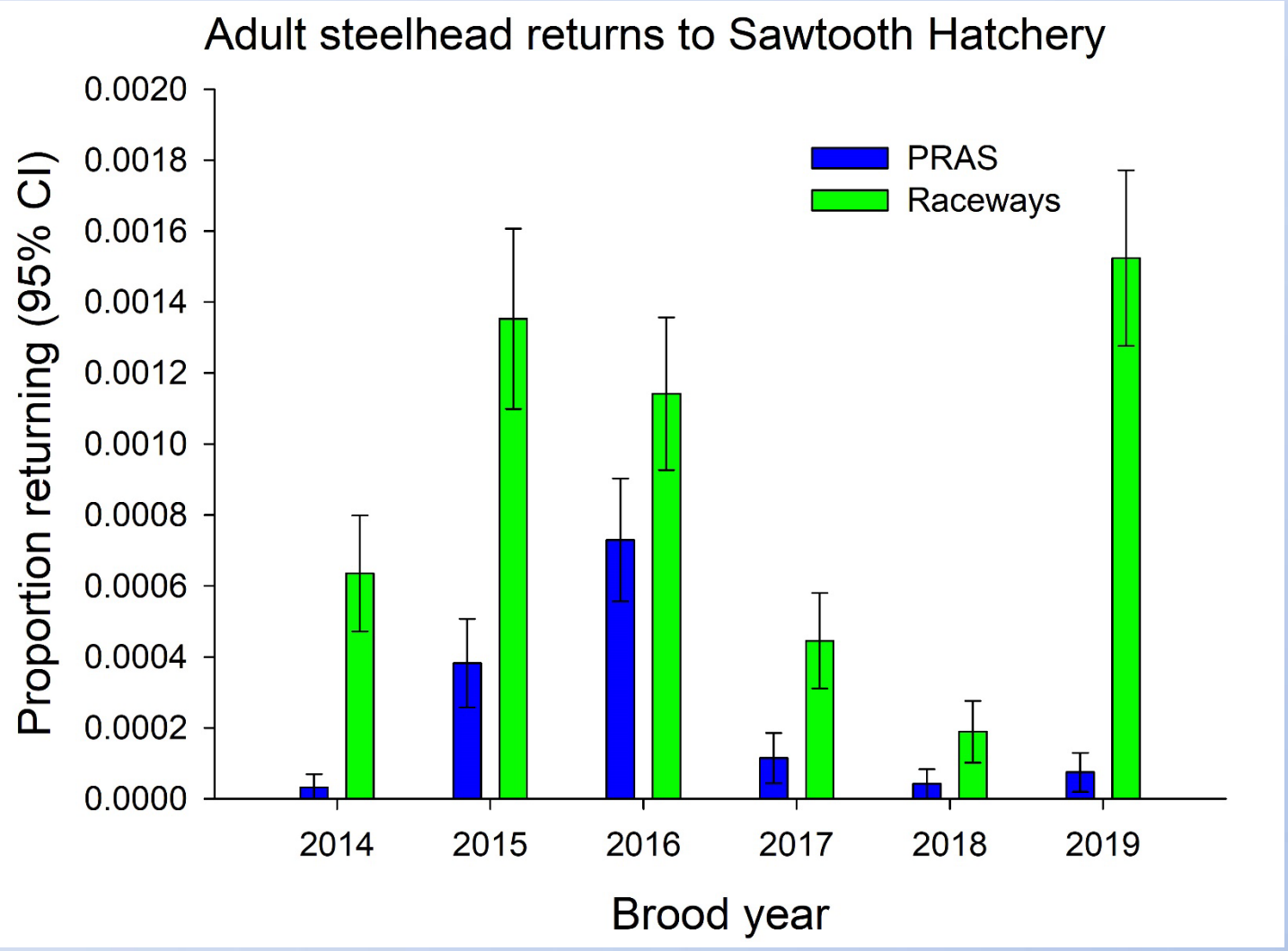
Survival to Lower Granite Dam as a function of April-May discharge in the Salmon River, 2015-2020



Tributary PIT Array Tag Detections 2015-2020



Adult Recoveries to Sawtooth Hatchery (IDFG)



Survivals to Hatchery Rack

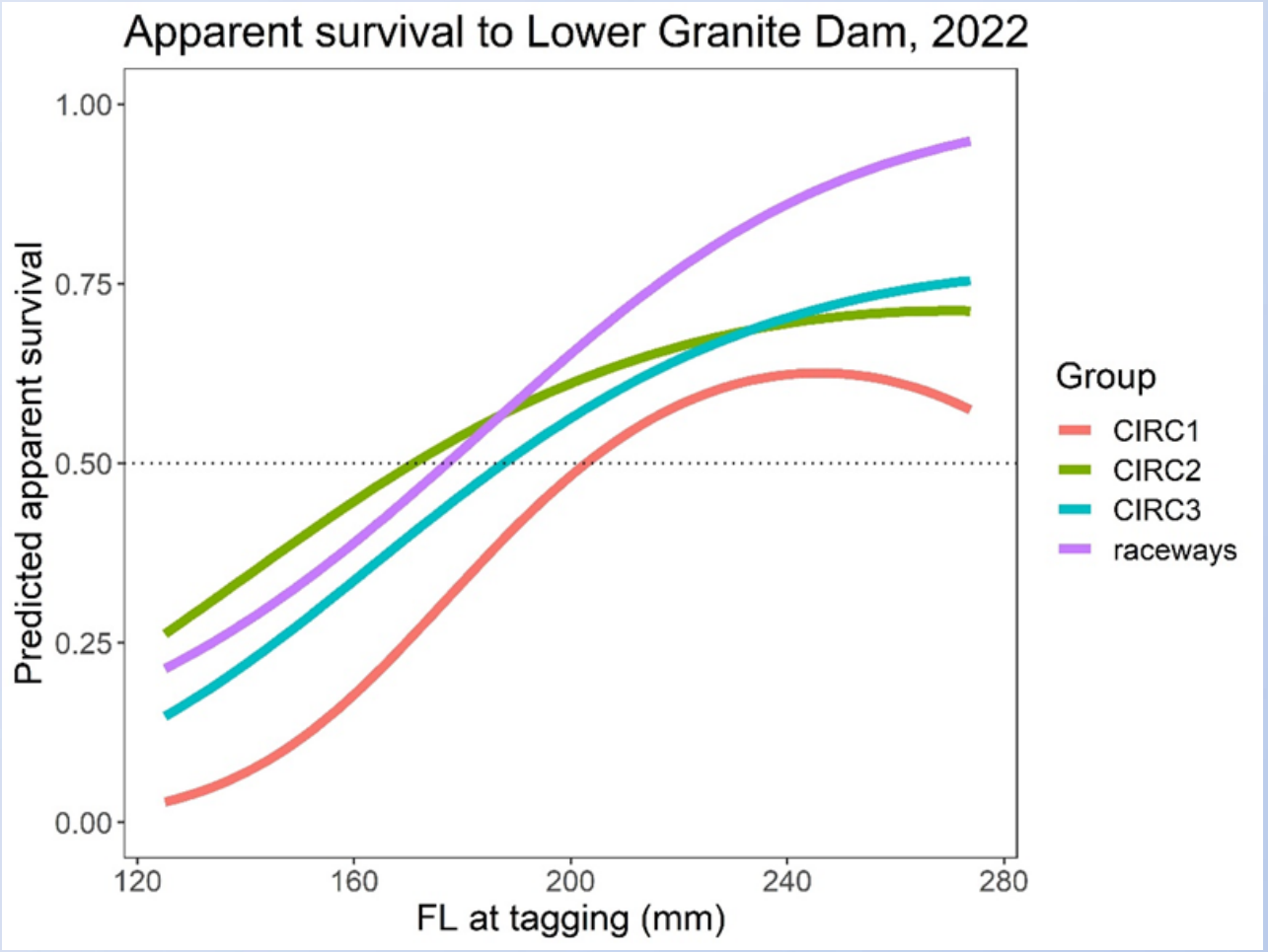
PRAS < Raceways in 6 of 6 years

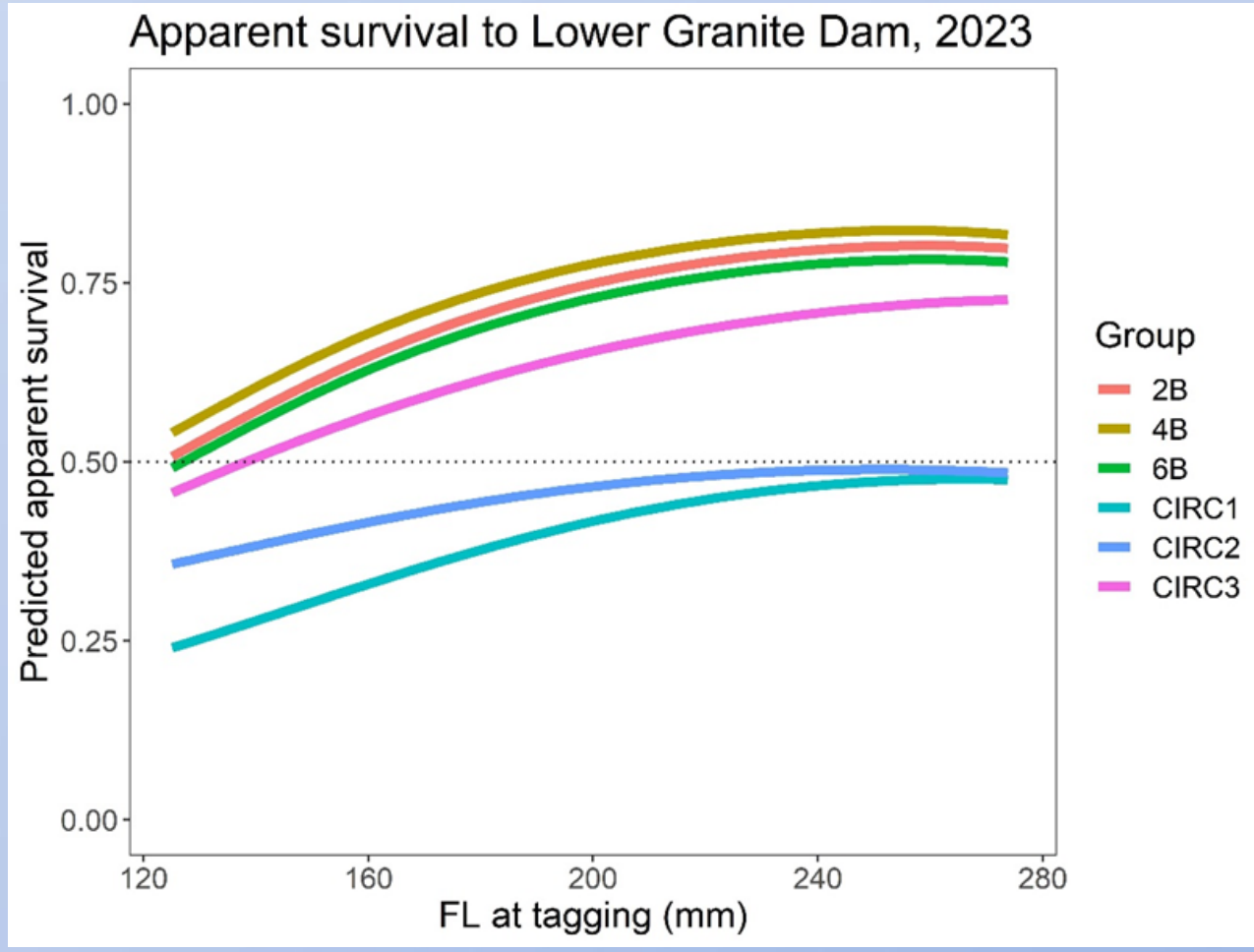
Data from A.

How much better/worse are the groups?

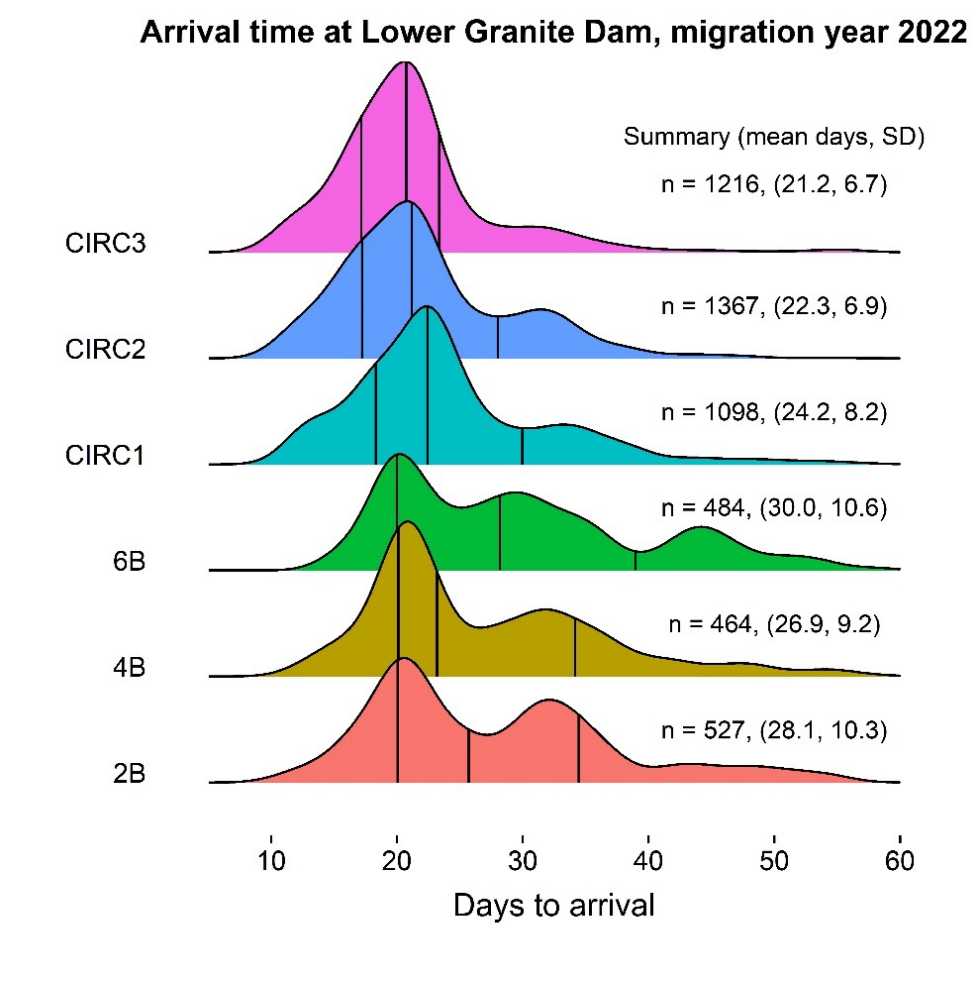
		BY 2014	BY 2015	BY 2016	BY 2017	BY 2018	BY 2019
Container	Est. production per container	MY 2015	MY 2016	MY 2017	MY 2018	MY 2019	MY 2020
PRAS (3)	30,000	0.003%	0.041%	0.080%	0.025%	0.004%	0.008%
LDC (3-4)	24,000	0.063%	0.137%	0.153%	0.091%	0.019%	0.152%
NDC (3)	27,000			0.118%	0.110%	0.038%	0.134%
		BY 2014	BY 2015	BY 2016	BY 2017	BY 2018	BY 2019
	LDC/PRAS	18.9	3.4	1.9	3.7	4.5	19.6
	NDC/PRAS			1.5	4.5	8.9	17.3
	LDC/NDC			1.3	0.8	0.5	1.1

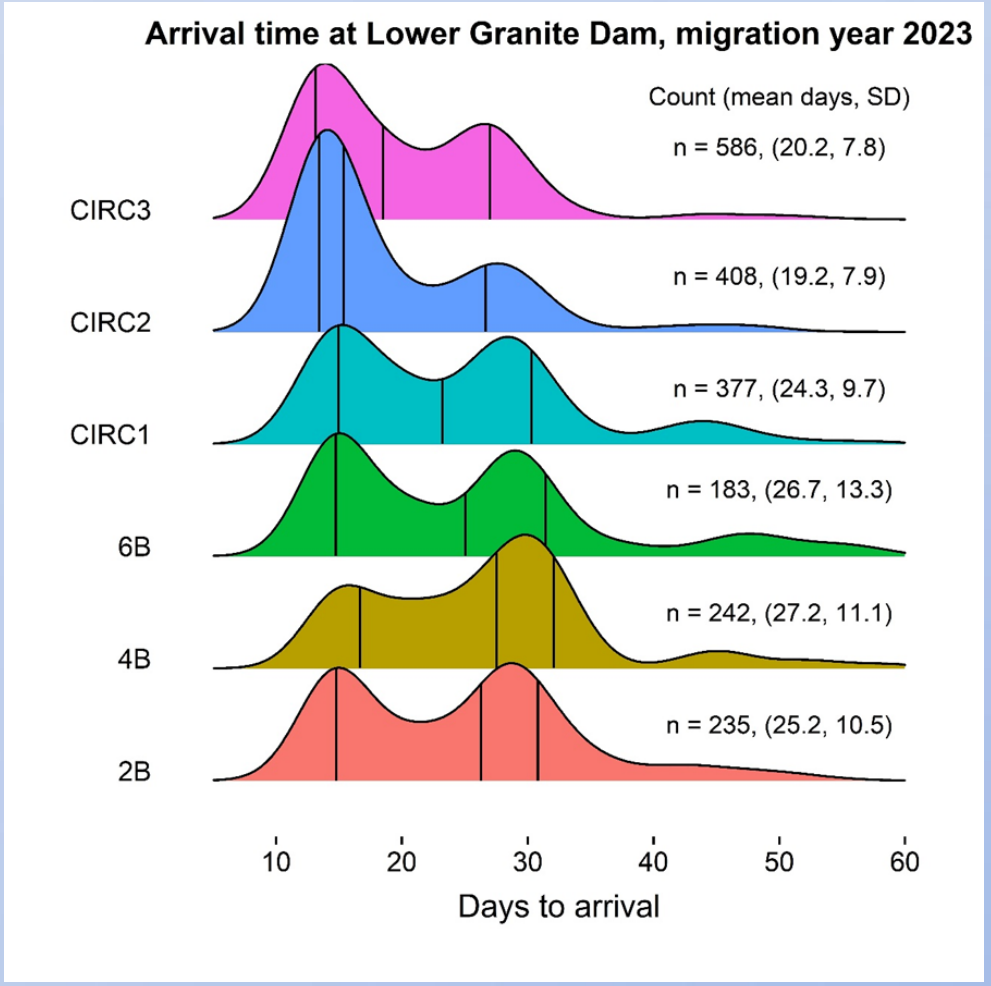
Apparent survival as a function of length, 2022-23 migration years



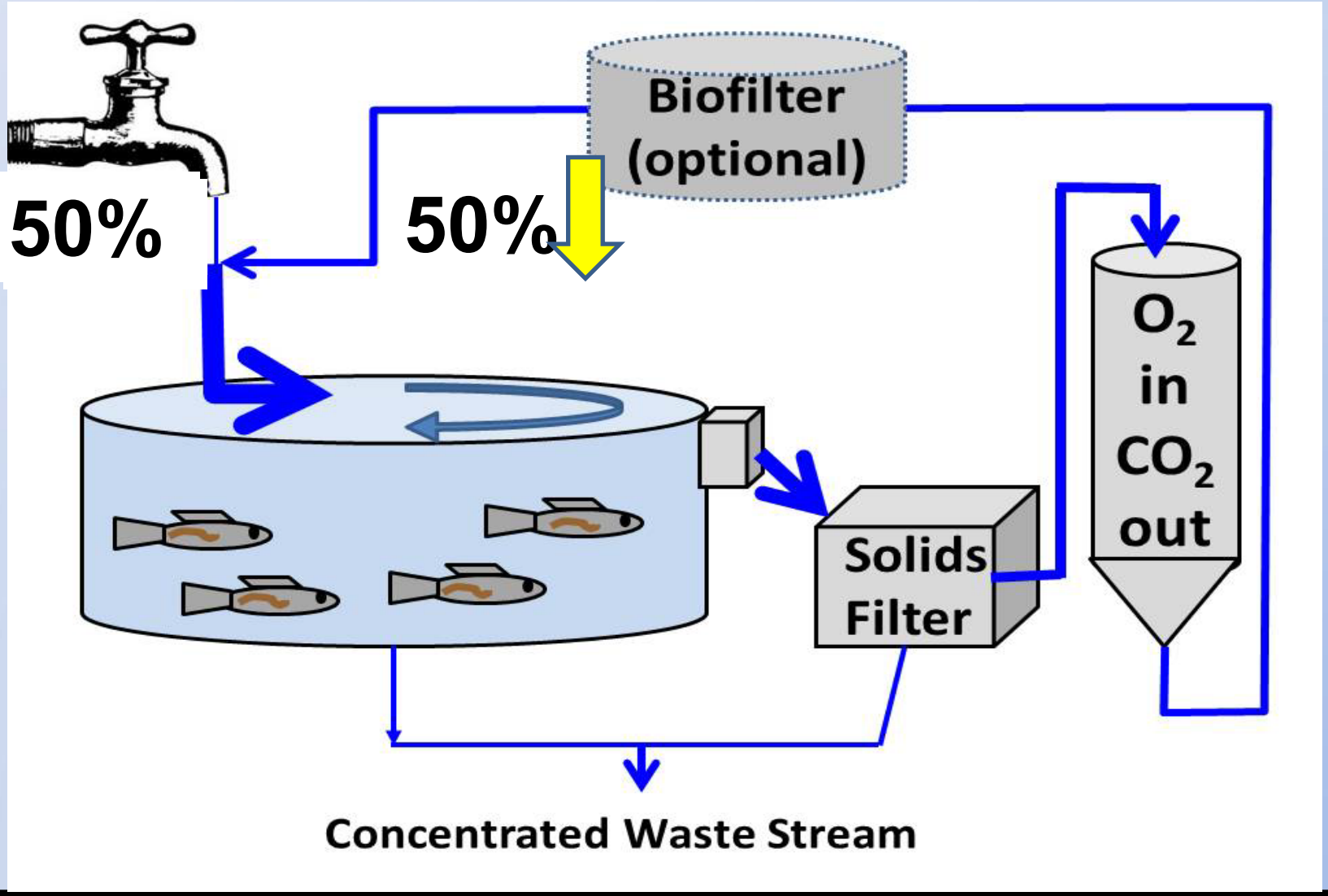


Days to arrival at Lower Granite Dam





Hagerman NFH Partial Reuse Aquaculture System (PRAS)

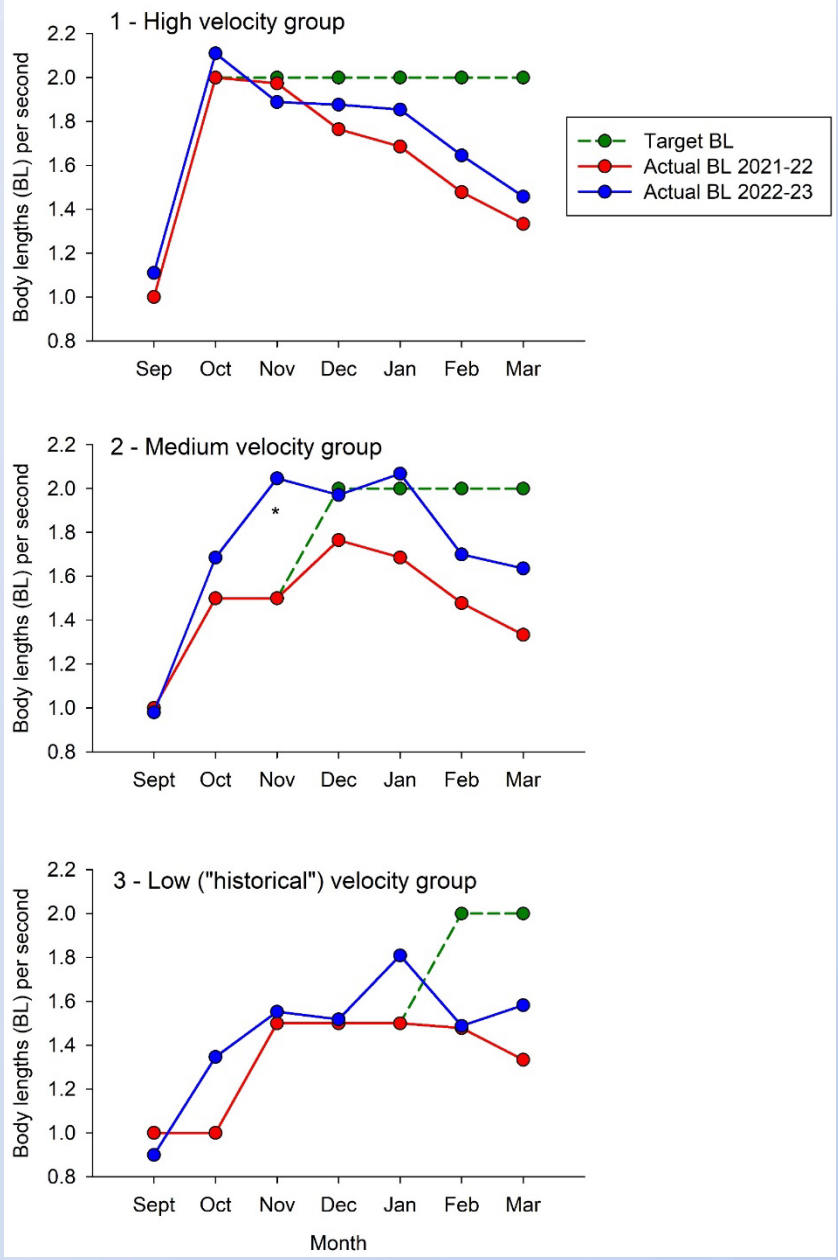


Summary

- As designed and executed, raceways “better” than PRAS for LSRCP Program at Hagerman NFH.
- Study revised for BY23 after discussions between IDFG and LSRCP.
  - “Supersmolt” feed evaluation for PRAS/Raceways
  - Tank velocities same, 1.5 BL/sec
  - Changed release time
  - Acclimated group
  - Report not finalized
- No production for BY24 – Upcoming discussion

- Many thanks to Hagerman NFH, USFWS-AFTC, USFWS-IDWCO and IDFG
  - Chris Peery (now with COE)
  - Andy Goodwin (PRAS graphics/animations), Jarrett Page - IDFWCO
  - Sage Pike, Brian Thompson, Brian Leth, Katie McBaine of IDFG for analyses and dedication.

Additional Slides



Velocity "Treatments" (BY21/22)

- Velocity treatments in 2023 were closer to target than in 2022
- Likely impossible given current infrastructure to attain 2 BL/s near the end of rearing

Delayed migration of PRAS fish during 2015-2019?

Detections of steelhead smolts at mainstem interrogation sites in release year + 1.

Release year	Release year + 1	Treatment group – rearing unit	Code	Dam
2015	2016	LDPC – RW74	3DA.1A19AEF1A9	GOJ
		LDPC – RW74	3DA.1A19AF5B55	GRJ
		PRAS – CIRC3	3DA.1A19AF58A1	LMJ
2016	2017	PRAS – CIRC1	3DD.003BE06369	JDJ
		PRAS – CIRC1	3DD.003BE2080E	GOJ
2017	2018	PRAS – CIRC3	3DD.0077771156	LJM
2018	2019	-	-	-
2019	2020	-	-	-

Rare and doesn't explain low PRAS survival in release year

Proximate Analysis (AFTC)

Migration Year	Group	Mean Weight (g)	Moisture (%)	Ash (%)	Crude Protein (%)	Lipid (%)
2015	PRAS	94.3	71.8	2.4	18.0	9.0 (a)
	Control	96.5	72.9	2.5	18.1	7.8 (b)
2016	PRAS	91.6	76.3	2.8	16.7	4.2 (a)
	Control	95.5	73.5	2.6	17.0	6.7 (b)

Proximate Analysis (AFTC)

Sample Date	Group	Lipid %
1/24/2017	PRAS	5.8 (a)
	Control 1	7.2 (b)
	Control 2	7.7 (b)
2/14/2017	PRAS	6.0 (a)
	Control 1	7.1(b)
	Control 2	7.2(b)
3/15/2017	PRAS	6.7 (a)
	Control 1	8.0 (b)
	Control 2	7.2 (ab)
3/28/2017	PRAS	6.6
	Control 1	6.7
	Control 2	6.8

Fish Culture (HNFH)

MY 16 and 17

	RAS	RAS Control 1	RAS Control 2
Fish/lb	5.25	4.89	4.83
Eyed Egg to Smolt	99.3%	87.7%	77.1%
Feed Fed	17,287	39,377	18,930
Conversion	0.96	1.37	1.39
DI	0.19	0.19	0.20

	RAS	RAS Control 1	RAS Control 2
Fish/lb	5.01	4.50	5.23
Eyed Egg to Smolt	99.2%	98.2%	98.5%
Feed Fed	20,603	21,701	17,878
Conversion	1.11	1.03	1.17
DI	0.20	0.20	0.23

Goedes Normality Index (PRFHP)
MY 15 and 16